

Processes at Sloping Boundaries in the Coastal Ocean

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LONG-TERM GOALS

To understand and parameterize interior and near-boundary mixing processes.

To understand the dynamical processes occurring in the surface layer of the ocean and parameterize them in ocean models.

To understand the physical oceanography of semi-enclosed seas.

OBJECTIVES

A current objective is to exploit Juan de Fuca Strait as a natural laboratory for the study of rotating stratified shear flows with sloping lateral boundaries. In particular I would like to understand and quantify vertical and lateral momentum transfer, the causes and role of cross-strait secondary circulation, and the comparative importance, magnitude and parameterization of internal and near-boundary mixing.

In the surface mixed layer I would like to understand and parameterize the effects of processes currently omitted from models.

For semi-enclosed seas I seek the key physics that controls the overall behavior.

APPROACH

For the last three summers we have conducted observational studies in Juan de Fuca Strait involving one or more bottom-mounted 300 kHz broadband ADCPs, temperature and conductivity moorings, and CTD, turbidity and microstructure sections. Senior Research Associate Richard Dewey assumes much of the responsibility for this, with assistance from postdoctoral fellow Kate Stansfield. Graduate students Michael Ott and Keir Colbo are also involved and will be basing their Ph.D. theses on various aspects of the work. Ship time has been provided by Canadian funding.

For surface mixed layer investigations, graduate student Konstantin Zahariev has used numerical models to investigate the effects of internal wave heaving of the base of the layer.

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Graduate student Elina Tragou has been investigating the overall forcing and dynamics of the Red Sea.

WORK COMPLETED

In 1998 we obtained a four week data set in the middle of the Strait of Juan de Fuca, with an ADCP moored on the bottom at 130 metres and two nearby T/C chains. We also moored an ADCP belonging to Parker MacCready of the University of Washington on the bottom at 100 metres on the steep southern side of the Strait, along with our third T/C chain. Numerous CTD profiles were also obtained and are being analysed with particular interest in determining the Thorpe scales as a measure of mixing. Some microstructure data were also obtained. Analysis of data obtained in earlier years has also proceeded. This has included the determination of lateral eddy momentum fluxes in a tidal channel. Analysis of Thorpe scales from previous CTD profiles obtained in the region has been completed. The laboratory experiment of Johnson and Ohlsen (1994) on rotating exchange flow has been repeated and extended to different parameters.

A numerical study of the effect of internal wave heaving on the seasonal cycle of surface mixed layer properties has been completed.

An assessment of the overall heat and freshwater budgets of the Red Sea, and their implications for the global reliability of data sets such as the COADS, has been completed.

RESULTS

The 1998 data set is currently being analysed for the mean, estuarine, flow, the tidal currents and the vertical and horizontal Reynolds stresses arising from higher frequency motions. One preliminary result is that the cross-strait secondary flows seen in the 1996 data are absent in the 1998 data, perhaps due to weaker mean shear, though the sensitivity is surprising. We have found that the lateral “eddy viscosity” in a tidal channel can be obtained, though this is hampered by lack of a clear spectral gap between tides and eddies. Analysis of good CTD profiles suggests that vertical mixing in regions such as this can be obtained with reasonable reliability from the Thorpe scale as this is not greatly affected by the small, unreliably determined, overturns. Our repeat and extension of Johnson and Ohlsen’s (1994) laboratory experiment has pointed to low frequency instabilities in part of parameter space.

For the surface mixed layer, it seems that the “background diffusivity” often arbitrarily added to models may actually be a proxy for the effects of internal wave heaving. Zahariev has proposed a more reliable parameterisation based on changing the stability criterion in a PWP model that neglects internal waves by an amount dependent on the internal wave amplitude.

Studies of the Red Sea suggest a major attenuation of insolation by atmospheric aerosols. We also suspect that the UWM/COADS global correction of trends in voluntary observing ship wind speeds is unreliable regionally.

IMPACT/APPLICATIONS

Our results should clarify the comparative importance for estuarine circulation of internal vertical friction and lateral friction at the sloping sides. It will also provide a better understanding of the contribution to cross-strait secondary flows of internal Ekman layers, converging bottom Ekman layers on the sloping sides and the density driven flow of boundary-mixed fluid. Refined procedures for the evaluation of Thorpe scales from CTD profiles may lead to more reliable determination of mixing rates in estuaries and on the continental shelf. Overall, we hope that results obtained in Juan de Fuca Strait will lead to understanding and parameterizations of general relevance.

Understanding of the effect of internal wave heaving on the mixed layer should lead to model improvement.

Our studies of the Red Sea could lead to more caution in the use of standard data sets as surface forcing functions for ocean models.

TRANSITIONS

We are collaborating with scientists at the University of Washington.

RELATED PROJECTS

The projects described above are also supported by Canadian funding agencies. Other projects underway include an analysis of long-term sea level and other data from the vicinity of the Strait of Gibraltar in a continued exploration of the maximal or submaximal nature of the exchange.

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